

1 WHAT IS CLAIMED IS:

- 1 1. An optical communications system for communicating an information signal comprising:
2 a receiver for recovering an information signal from an optical signal containing the
3 information signal, the receiver comprising:
4 a heterodyne detector for mixing an optical local oscillator signal with an optical
5 signal including at least one tone and a first sideband of the information
6 signal, to produce an electrical signal which is a frequency down-shifted
7 version of the optical signal; and
8 a signal extractor coupled to the heterodyne detector for mixing the first sideband
9 of the electrical signal with one of the tones of the electrical signal to
10 produce a first component containing the information signal.
- 11 2. The optical communications system of claim 1 wherein the heterodyne detector
12 comprises:
13 an optical combiner for combining the optical local oscillator signal and the optical
14 signal; and
15 a square law detector disposed to receive the combined optical local oscillator signal and
16 optical signal.
- 17 3. The optical communications system of claim 2 wherein the heterodyne detector further
18 comprises:
19 a polarization controller coupled to the optical combiner for matching a polarization of
20 the optical local oscillator signal with a polarization of the optical signal.
- 21 4. The optical communications system of claim 1 wherein the signal extractor comprises:
22 a first frequency filter for selecting the first sideband and one of the tones from the
23 electrical signal;

4 a square law device coupled to the first frequency filter for squaring the frequency
5 selected first sideband and tone to produce the first component; and
6 a second frequency filter coupled to the square law device for selecting the first
7 component.

1 5. The optical communications system of claim 1 wherein the signal extractor comprises:
2 a first frequency filter for selecting the first sideband from the electrical signal;
3 a second frequency filter for selecting one of the tones from the electrical signal;
4 a multiplier coupled to the first and second frequency filters for multiplying the selected
5 first sideband with the selected tone to produce the first component; and
6 a third frequency filter coupled to the multiplier for selecting the first component.

1 6. The optical communications system of claim 1 wherein:
2 the optical signal further includes a second sideband of the information signal; and
3 the signal extractor comprises:
4 a first extraction path for mixing the first sideband of the electrical signal with one
5 of the tones of the electrical signal to produce the first component;
6 a second extraction path for mixing the second sideband of the electrical signal
7 with one of the tones of the electrical signal to produce a second
8 component; and
9 a combiner for constructively combining the first and second components to
10 produce a resultant component containing the information signal.

1 7. The optical communications system of claim 6 wherein the first extraction path overlaps
2 with the second extraction path.

1 8. The optical communications system of claim 6 wherein each of the first and second
2 extraction paths comprises:

3 a first frequency filter for selecting the relevant sideband and tone from the electrical
4 signal;
5 a square law receiver coupled to the first frequency filter for squaring the frequency
6 selected sideband and tone to produce the component; and
7 a second frequency filter coupled to the square law receiver for selecting the component.

- 1 9. The optical communications system of claim 6 wherein each of the first and second
2 extraction paths comprises:
3 a first frequency filter for selecting the relevant sideband from the electrical signal;
4 a second frequency filter for selecting the relevant tone from the electrical signal;
5 a multiplier coupled to the first and second frequency filters for multiplying the selected
6 sideband with the selected tone to produce a component; and
7 a third frequency filter coupled to the multiplier for selecting the component.

- 1 10. The optical communications system of claim 6 wherein the combiner comprises:
2 a phase shifter coupled to the first extraction path for phase-shifting the first component
3 to be in-phase with the second component; and
4 an adder for adding the phase-shifted first component and the second component.

- 1 11. The optical communications system of claim 1 wherein the tone includes a carrier for the
2 optical signal.

- 3 12. The optical communications system of claim 1 wherein the tone includes a pilot tone
4 located at a frequency separated from a carrier frequency for the optical signal.

- 5 13. The optical communications system of claim 1 wherein the first component includes a
6 difference component.

- 1 14. The optical communications system of claim 1 further comprising:
2 a transmitter for generating the optical signal.

1 15. The optical communications system of claim 14 wherein the transmitter comprises:
2 a 1:3 splitting section, for splitting a received optical carrier into three sub-signals;
3 a first and a second transmission leg, each leg coupled to receive one of the three sub-
4 signals from the 1:3 splitting section, for modulating the received optical carrier
5 with a received information signal;
6 a third transmission leg, coupled to receive one of the three sub-signals from the 1:3
7 splitting section, for producing an unmodulated version of the received optical
8 carrier; and
9 a 3:1 combining section coupled to the first, second and third transmission legs, for
10 combining the modulated optical carrier with the unmodulated optical carrier.

1 16. A transmitter comprising:
2 a 1:3 splitting section, for splitting a received optical carrier into three sub-signals;
3 a first and a second transmission leg, each leg coupled to receive one of the three sub-
4 signals from the 1:3 splitting section, for modulating the received optical carrier
5 with a received information signal;
6 a third transmission leg, coupled to receive one of the three sub-signals from the 1:3
7 splitting section, for producing an unmodulated version of the received optical
8 carrier; and
9 a 3:1 combining section coupled to the first, second and third transmission legs, for
10 combining the modulated optical carrier with the unmodulated optical carrier.

1 17. The transmitter of claim 16 wherein the third transmission leg includes a control section
2 for controlling an amplitude of the unmodulated optical carrier.

1 18. The transmitter of claim 16 wherein the third transmission leg includes a control section
2 for controlling a phase of the unmodulated optical carrier.

1 19. A transmitter comprising:

2 a combiner for combining a received pilot tone with a received information signal to
3 produce an intermediate signal; and
4 an optical modulator for modulating a received optical carrier with the intermediate
5 signal.

1 20. The transmitter of claim 19 wherein the optical modulator includes a Mach-Zender
2 modulator.

1 21. A method for recovering an information signal from an optical signal containing the
2 information signal, the method comprising:

3 receiving an optical signal including at least one tone and a first sideband of the
4 information signal;
5 receiving an optical local oscillator signal at a frequency f_{LO} ;
6 detecting the optical signal using heterodyne detection and the optical local oscillator
7 signal to produce an electrical signal which is frequency down-shifted by the
8 amount f_{LO} with respect to the optical signal; and
9 mixing the first sideband of the electrical signal with one of the tones of the electrical
10 signal to produce a first component containing the information signal.

1 22. The method of claim 21 wherein the step of detecting the optical signal comprises:
2 combining the optical local oscillator signal and the optical signal; and
3 detecting the combined optical local oscillator signal and optical signal using square law
4 detection.

1 23. The method of claim 22 wherein the step of detecting the optical signal further comprises:
2 matching a polarization of the optical local oscillator signal with a polarization of the
3 optical signal.

1 24. The method of claim 21 wherein the step of mixing the first sideband of the electrical
2 signal with one of the tones of the electrical signal comprises:

3 frequency filtering the first sideband and the tone from the electrical signal;
4 squaring the first sideband and tone to produce the first component; and
5 frequency filtering the first component.

1 25. The method of claim 21 wherein the step of mixing the first sideband of the electrical
2 signal with one of the tones of the electrical signal comprises:

3 frequency filtering the first sideband from the electrical signal;
4 frequency filtering the tone from the electrical signal;
5 multiplying the first sideband with the tone to produce the first component; and
6 frequency filtering the first component.

1 26. The method of claim 21 wherein:

2 the optical signal further includes a second sideband of the information signal; and
3 the method further comprises:

4 mixing the second sideband of the electrical signal with one of the tones of the
5 electrical signal to produce a second component containing the
6 information signal; and

7 constructively combining the first and second components to produce a resultant
8 component containing the information signal.

1 27. The method of claim 26 wherein:

2 the step of mixing the first sideband of the electrical signal with one of the tones of the
3 electrical signal comprises:

4 frequency filtering the first sideband and the tone from the electrical signal;
5 squaring the first sideband and tone to produce the first component; and
6 frequency filtering the first component; and

7 the step of mixing the second sideband of the electrical signal with one of the tones of the
8 electrical signal comprises:

9 frequency filtering the second sideband and the tone from the electrical signal;

10 squaring the second sideband and tone to produce the second component; and
11 frequency filtering the second component.

- 1 28. The method of claim 26 wherein:
2 the step of mixing the first sideband of the electrical signal with one of the tones of the
3 electrical signal comprises:
4 frequency filtering the first sideband from the electrical signal;
5 frequency filtering the tone from the electrical signal;
6 multiplying the first sideband with the tone to produce the first component; and
7 frequency filtering the first component; and
8 the step of mixing the second sideband of the electrical signal with one of the tones of the
9 electrical signal comprises:
10 frequency filtering the second sideband from the electrical signal;
11 frequency filtering the tone from the electrical signal;
12 multiplying the second sideband with the tone to produce the second component;
13 and
14 frequency filtering the second component.

1 29. The method of claim 26 wherein the step of constructively combining the first and second
2 components comprises:

3 phase-shifting the first component to be in-phase with the second component; and
4 adding the phase-shifted first component and the second component.

1 30. The method of claim 21 wherein the tone includes a carrier for the optical signal.

1 31. The method of claim 30 further comprising:
2 modulating an optical carrier with the information signal using a raised cosine
3 modulation biased at a V_{π} point; and

4 combining the modulated optical carrier with an unmodulated optical carrier to produce
5 the optical signal.

- 1 32. The method of claim 30 further comprising:
2 modulating an optical carrier with the information signal using a raised cosine
3 modulation biased at a point slightly offset from a V_{π} point to produce the optical
4 signal.
- 1 33. The method of claim 21 wherein the tone includes a pilot tone located at a frequency
2 separated from a carrier frequency for the optical signal.
- 1 34. The method of claim 33 further comprising:
2 combining the information signal with a pilot tone; and
3 modulating an optical carrier with the combined information signal and pilot tone using a
4 raised cosine modulation biased at a V_{π} point.

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